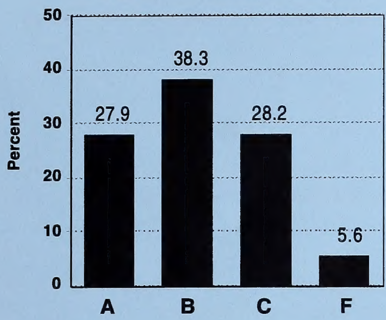
Physics 30

Diploma Examination Results
Examiners' Report for January 1995

School-Awarded Mark

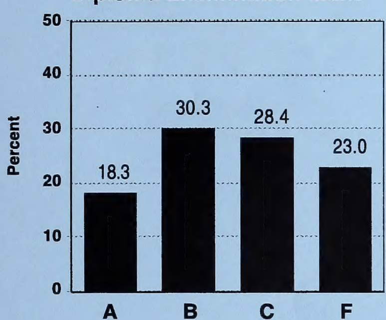


The summary information in this report provides teachers, school administrators, students, and the general public with an overview of results from the January 1995 administration of the Physics 30 Diploma Examination. This information is most helpful when used with the detailed school and jurisdiction reports that have been mailed to schools and school jurisdiction offices. An annual provincial report containing a detailed analysis of the combined January, June, and August results is published each year.

Description of the Examination

The Physics 30 Diploma Examination consists of 37 multiple-choice questions worth 52.9%, 12 numerical-response questions worth 17.1%, and two written-response questions worth 30% of the total examination.

Diploma Examination Mark



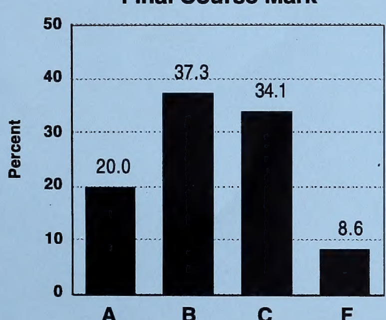
Achievement of Standards

The information reported is based on the final course marks achieved by 2 809 students in Alberta who wrote the January 1995 examination. This represents a decrease of 277 students compared to June 1994, and a decrease of 524 students compared to January 1993.

- 91.4% of the 2 809 students achieved the acceptable standard (a final course mark of 50% or higher).
- 20.0% of these students achieved the standard of excellence (a final course mark of 80% or higher).

Students showed a basic understanding of the course content and performed well solving problems that required calculations. However, students experienced difficulty interpreting information with a context that may have been unfamiliar to them, and then applying their knowledge of physics to solve problems. In addition, students continue to have problems applying the abstract concepts of electric and magnetic fields. Students also experienced difficulty demonstrating their ability to solve problems involving two-dimensional interactions requiring vector analysis.

Final Course Mark



Approximately 36.2% of the students who wrote the examination were female. Approximately 94.1% of this female population achieved the acceptable standard on the examination, as did 89.9% of the male population. Approximately 18.9% of this female population achieved the standard of excellence on the examination, compared to 20.7% of the male population. The average examination mark achieved by the female population (36.2%) was 63.2%, and by the male population (63.8%), it was 63.3%.

Students First!
Student Evaluation

Alberta
EDUCATION

Provincial Averages

- The average school-awarded mark was 70.0%.
- The average diploma examination mark was 63.3%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 67.0%.

Approximately 7.1% of the students who wrote the examination in January 1995 and received a school-awarded mark had previously written at least one other Physics 30 Diploma Examination during the August 1993 to August 1994 period. This subpopulation (200) achieved an examination average of 59.3% compared to 63.6% for the population (2 609) whose first writing of a Physics 30 examination was in January 1995. However, the group of students who rewrote (200) increased their examination average score from 50.5% to 59.3%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students capable of achieving the acceptable standard will obtain a mark of 50% or higher and students achieving the standard of excellence will obtain a mark of 80% or higher.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer. For multiple-choice and numerical-response questions, the "Difficulty" indicates the percentage of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score achieved by students who wrote the examination.

Questions are also classified by general learner expectations.

Knowledge–

- GLE 1 Explain gravitational, electrical, and magnetic effects on systems
- GLE 2 Analyze and predict the behaviour and physical interactions of objects
- GLE 3 Describe and analyze resistive circuits and the function of EM devices
- GLE 4 Solve problems related to EM wave behaviour and the atomic theory

Skills–

- SPSC Scientific Process Skills and Communication Skills.

Science, Technology, Society–

- STS Connections Among Science, Technology, & Society.

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPSC	STS
MC 1	C	81.4	√					
MC 2	A	79.4		√				
MC 3	C	49.9	√					
NR 1	7.50	77.2			√		√	√
NR 2	1.53	66.7			√		√	√
NR 3	1.63	87.1	√				√	√
NR 4	8.49*	68.8		√			√	√
MC 4	B	80.7	√				√	√
MC 5	C	59.0	√					√
MC 6	C	37.6			√		√	
MC 7	C	56.4		√				
MC 8	A	93.4	√					
MC 9	B	70.8	√					
MC 10	B	62.5	√					
MC 11	A	70.4	√					
NR 5	12.5	47.1	√				√	
MC 12	B	69.8	√				√	

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPSC	STS
MC 13	B	63.4		√			√	
NR 6	1.08*	30.7		√			√	
MC 14	deleted	–	–	–	–	–	–	–
MC 15	B	72.7		√				
MC 16	C	76.9		√				
MC 17	B	49.6		√				
NR 7	12.7	80.3			√		√	
MC 18	A	49.5				√		
NR 8	4.80	40.9				√	√	√
MC 19	D	58.4				√		
MC 20	A	44.1				√		√
MC 21	B	68.4				√		√
NR 9	4.59	78.7				√	√	
NR 10	2.94	55.0				√	√	
MC 22	B	63.0				√		
MC 23	A	59.7				√	√	√
MC 24	B	47.0				√	√	√
MC 25	D	68.1				√	√	√
MC 26	D	42.4				√		
MC 27	A	74.9				√		
MC 28	D	48.9				√		√
MC 29	B	84.8				√		√
MC 30	A	91.4				√		√
MC 31	D	85.2		√			√	
MC 32	C	83.8		√			√	
MC 33	A	49.3		√			√	
MC 34	D	82.9				√		√
MC 35	C	51.1		√				
NR 11	6.54	46.2				√	√	
NR 12	2.55	66.0		√			√	
MC 36	C	66.1		√				
MC 37	B	57.2		√				√
WR 1	–	76.1			√		√	√
WR 2	–	45.6		√			√	√

* The answer to this question is dependent on the answer selected or calculated on the preceding question. As a result, there are alternate solutions that are acceptable.

Subtest: Multiple Choice, Numerical Response and Written Response

When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared. Results are in average raw scores.

- General Learner Expectations:

GLE 1	Explain gravitational, electrical, and magnetic effects on systems	7.7	out of	11
GLE 2	Analyze and predict the behaviour and physical interactions of objects	14.6	out of	26
GLE 3	Describe and analyze resistive circuits and the function of EM devices	10.2	out of	14
GLE 4	Solve problems related to EM wave behaviour and the atomic theory	11.0	out of	18
Skills	Scientific process and communication skills	15.6	out of	23
STS	Connections in science, technology, and society	24.0	out of	38

- Multiple choice and numerical response: 31.0 out of 48
  Multiple choice: 23.5 out of 4
  Numerical response: 7.5 out of 12

Results are in average raw scores.

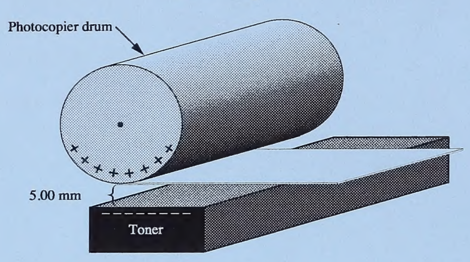
- Written Response: 12.6 out of 21
  Question 1: 7.6 out of 10
  Question 2: 5.0* out of 11
  Communication: 1.73* out of 3
  Content: 3.09 out of 8

* Individual student scores for Question 2 are equal to the Scale 1 score added to the Scale 2 score, then rounded to a whole number before calculating the final average raw score for Question 2.

Multiple-Choice and Numerical-Response Questions

The following questions were selected for discussion because they exemplify what is required to meet the acceptable standard and the standard of excellence.

Photocopier



Assume that the beads of toner (dry ink) and letters on the drum act as point charges. The charge on each bead of toner is -6.40×10^{-16} C and the average charge on the part of the drum with the image of the letter copied is $+7.10 \times 10^{-13}$ C.

Numerical Response

3. When the toner and the drum are separated by 5.00 mm, the force of attraction between the letter and the toner bead, expressed in scientific notation, is $b \times 10^{-13}$ N.
The value of b is ___________.

(Round and record your answer to three digits on the answer sheet.)

Answer: **1.63**

Numerical Response

Use your answer from ***Numerical Response 3*** *to answer* ***Numerical Response 4.***

4. Each coated bead in the photocopier has an average mass of 1.92×10^{-15} kg. The acceleration of a bead toward the drum, expressed in scientific notation, is $b \times 10^{w}$ m/s^2. Ignoring the presence of gravity, the value of b is _____ .

(Round and record your answer to three digits on the answer sheet.)

Answer: **8.49**

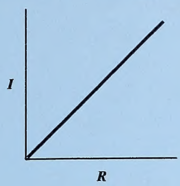
Numerical-response question 3: Many students (87.1%) were able to interpret the information presented in the context of the photocopier, select a formula that could be used to determine the force of attraction between the letter and the toner head, and then correctly calculate the force of attraction. What is encouraging here is that students were able to transfer their understanding of electrostatics to a technology that exists in everyday life. Of the students who achieved the standard of excellence, 96.9% answered the question correctly. Of the students who achieved the acceptable standard but not the standard of excellence, 90.7% answered the question correctly. Even 70.1% of the students who did not achieve the acceptable standard chose the correct answer.

Numerical-response question 4: To successfully answer this question, students were required to use their answer from numerical-response question 3. Using their answer from numerical-response question 3, students had to shift from their knowledge of electrostatics to their understanding of Newton's 2nd Law. In turn, they were required to apply this understanding to determine the acceleration of a bead toward the drum, neglecting any effects gravity would have on the bead. Of all students, 68.8% were able to answer this question correctly. Of the students who achieved the standard of excellence, 85.0% answered correctly; whereas, 72.1% of the students who achieved the acceptable standard but not the standard of excellence answered the question correctly. Of the students who did not achieve the acceptable standard, 47.5% answered the question correctly. Again, many students successfully transferred their understanding of the acceleration of a mass due to the presence of unbalanced force and apply it to the technology incorporated in a photocopier.

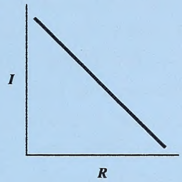
Numerical-response (NR) question 3 and 4 are linked to one another. In NR question 3, the student is required to generate a numerical response for the force of attraction between the letter and the toner bead. Numerical-response question 4 requires that the students use their answer from NR question 3 to generate a numerical response for the acceleration of the bead toward the drum. If the student recorded an incorrect answer for NR question 3, but used that numerical value correctly in NR question 4, then the student's response was scored correct. The student could use the non-rounded answer from NR question 3 as an intermediate value when calculating the answer for NR question 4. Both variations described above can be accommodated by the programming designed for electronic scoring.

6. Which graph shows the relationship between current I and resistance R for resistors that obey Ohm's law and are connected to a constant potential difference?

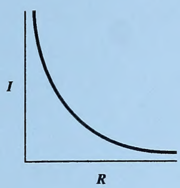
A.



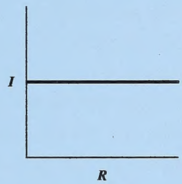
B.



•C.



D.



Multiple-choice question 6: Student performance on this question was lower than expected. Students were required to identify the shape of a graph that corresponded to the relationship between current and resistance when the potential difference is constant. Or, using the simpler terms of Ohm's Law (V = IR), when V (voltage) is constant, students had to determine the relationship between I (current) and R(resistance). Many students experienced difficulty applying their knowledge of Ohm's Law in this question. Of the students who achieved the standard of excellence, 47.3% answered the question correctly. Of the students who achieved the acceptable standard but not the standard of excellence, 38.2% answered correctly. Of the students who did not achieve the acceptable standard, only 28% answered correctly. Many students lack a clear understanding of Ohm's Law and the relationship between voltage, current, and resistance. Students may not have experienced the validation of Ohm's Law in a laboratory setting, or perhaps they are unfamiliar with generating data that, in turn, demonstrates an understanding of the relationship between two variables.

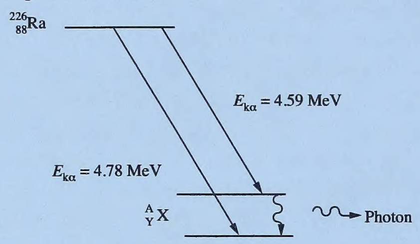
I	Oscillating magnet
II	Accelerating proton
III	Steady electric current
IV	Stationary electron

18. The phenomena that produce an electromagnetic wave are

•A. I and II
B. I and III
C. II and IV
D. III and IV

Multiple-choice question 18: Students were required to identify from a list of four phenomena, two that would produce an electromagnetic wave. Of all students, 39.5% have the incorrect understanding that an electromagnetic wave can be produced by a steady electric current as opposed to an accelerating proton. However, fundamental to the understanding of electromagnetic waves is that they are produced by an accelerating charge. Knowing how an electromagnetic wave is produced greatly assists students in conceptualizing other EM phenomena. Of the students who achieved the standard of excellence, 78.6% answered the question correctly. Of the students who achieved the acceptable standard but not the standard of excellence, 50.0% answered correctly. Of the students who did not achieve the acceptable standard, only 25.1% answered the question correctly.

In the decay of $^{226}_{88}Ra$, two groups of alpha particle energies are observed.



The difference in kinetic energy between the alpha particles can be accounted for by the release of a photon.

Numerical Response

11. The wavelength of the emitted photon, expressed in scientific notation, is $b \times 10^{-w}$ m. The value of b is ____ .

(Round and record your answer to three digits on the answer sheet.)

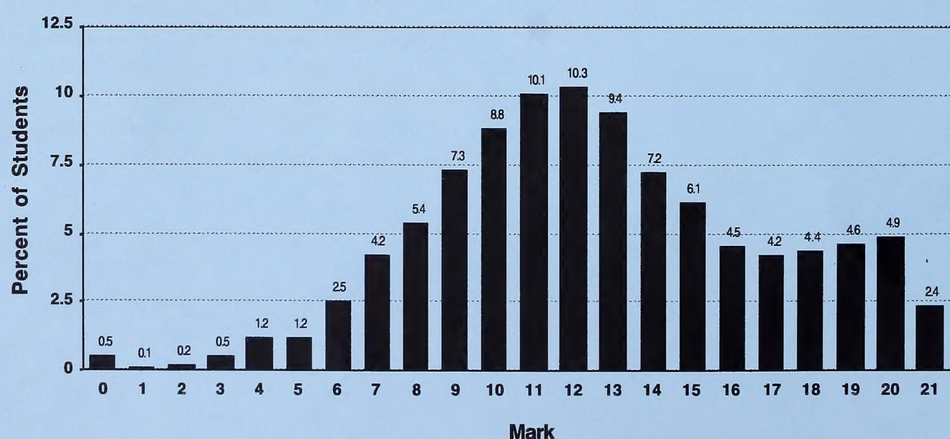
Answer: **6.54**

Numerical-response question 11: In the decay of $^{226}_{88}$ Ra, the difference between alpha particle energies can be accounted for by the release of a photon of a specific frequency or wavelength. Students were required to interpret the alpha particle energy diagram and use the data presented to first calculate the energy difference between the two groups of alpha particle energies. Next, students had to determine the wavelength of the emitted photon that would have an energy equal to the energy difference of the alpha particle energies. Of all students, 46.2% answered the question correctly. Of the students who achieved the standard of excellence, 81.5% answered the question correctly. Of the students who achieved the acceptable standard but not the standard of excellence, 48.8% answered correctly. Of the students who did not achieve the acceptable standard, 11.6% answered the question correctly. Of all students, 10.1% recorded an answer of 1.05. This value is consistent with the procedure where students neglect to convert the energy difference between the two groups of alpha particles from electron-volts to joules during their calculation.

Written-Response Questions

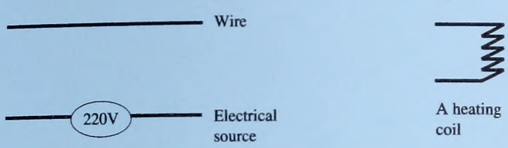
The level of achievement on the written-response questions was slightly lower than expected. Only 68.2% of all students received a mark of 11 or higher out of 21. The average mark on the written-response questions was 12.6 or 60.1%.

Distribution of Marks for Written Response



Written Response – 10 marks

Hot water in a domestic residence is produced by heating water in a tank. The heating source in many hot water tanks is provided by 220 V electrical coils that are placed in the tank. Each of the electrical coils has a resistance of 15 Ω.



1. **a.** Using the symbols above, draw the circuit diagram that would use two coils to heat the water in the shortest possible time.

   b. What current is provided by the 220 V source to the two heating coils?

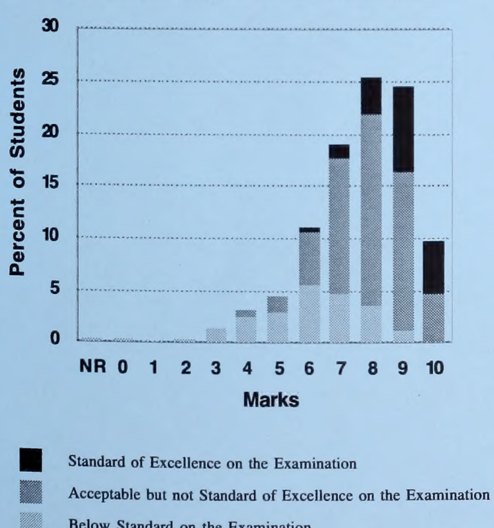
   c. What is the power consumed by each heating coil?

Use this additional information to answer the next question.

The amount of energy needed to heat water is given by the formula $E = mc\Delta T$, where m is the mass of water, c is the specific heat capacity of water, and ΔT is the change in temperature. The specific heat of water is 4.2×10^3 J/(°C•kg).

   d. How long in minutes will it take the two heating coils to raise the temperature of a tank containing 160 kg of water by 1.0° C? (If you were unable to determine the amount of consumed power in part **c**, use the hypothetical value $P = 3.55 \times 10^3$ W.)

Distribution of Marks for Question 1



Written-response question 1 was well answered. Students were required to draw a circuit diagram that would use two heating coils to heat water in the shortest possible time. In addition, students had to determine the current provided by the electrical source, calculate the power consumed by each heating coil, and compute the time it would take for their circuit to heat a given quantity of water. Of the students who achieved the standard of excellence, 90.9% earned a mark of 8 or better out of 10. Of the students who achieved the acceptable standard but not the standard of excellence, 95.9% earned a mark of 6 or better out of 10. Of the students who did not achieve the acceptable standard, 78.5% received a mark of 5 or better out of 10.

In part a, a common misconception that caused many students to lose a check or two is that they mistakenly believe that the greater the total resistance in a circuit, the greater the loss in energy. As a result of this belief, many students drew a circuit with the two heating coils in series, which, of course, has a much higher resistance than two heating coils in parallel. The series circuit would take longer to heat the water than would the parallel circuit.

In part b, students had little difficulty in applying their understanding of Ohm's Law to determine the current of 29A for the parallel circuit or 7.3 A for the series circuit. If anything, students lost a check for the number of significant digits in their answer.

When computing the power consumed by each heating coil in part c, students used either the rounded or non-rounded value for the current calculated in part b. In almost all solutions, students provided formula, correct substitution, and an accurate final answer with appropriate units. Students solving for power consumed by one coil in the parallel circuit used one-half of the current calculated in part b (Kirchoff's Laws). Those that solved for power consumed by one coil in the series circuit correctly used one-half of the voltage supplied by the electrical source as the potential drop.

Part d required students to interpret the use of a formula that could be used to determine how much energy is required to change the temperature of a specified quantity of water. Students had little difficulty in calculating the energy required to heat the water. Some experienced difficulty when they had to determine the time required to raise the temperature of 160 kg of water 1.0°C. These students had trouble making the connection between the energy and the work needed to increase the temperature of the water. The heating oils connected in series would take 7.0 min; whereas, the coils in parallel would take only 1.8 min.

On this 10-mark question, the average mark was 7.6 or 76.1%.

Written Response – 10 marks

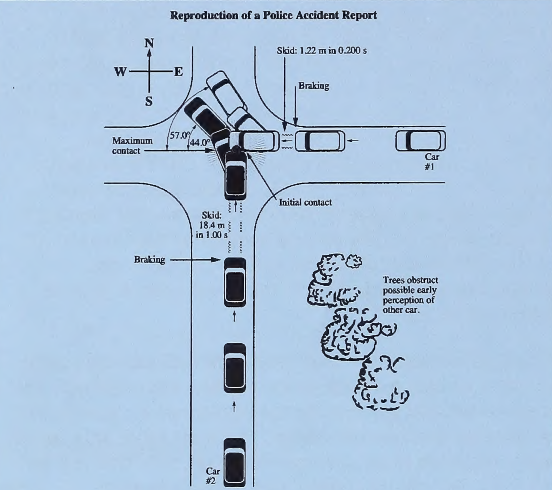


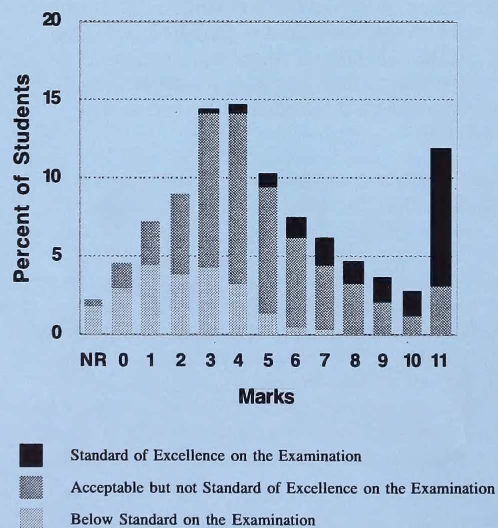
Diagram is not to scale.

2. After measuring and evaluating skid marks, police were able to determine that Car #1, of mass 765 kg, was travelling at 70.0 km/h just after the impact. Car #2, of mass 1100 kg, was determined to be moving at 41.0 km/h just after impact. In analyzing this accident scene, it is important for police to establish the velocity of each car just before impact.

Describe in detail and **show how** the police investigator would calculate the velocities of both cars just before collision.

Note: A maximum of 8 marks will be awarded for the physics used to solve this problem. A maximum of 3 marks will be awarded for the effective communication of your response.

Distribution of Marks for Question 2



Written-response question 2 was not answered as well as expected. Students were required, most importantly, to recognize that this was a question that involved their knowledge of the Law of Conservation of Momentum. Using their understanding of two-dimensional vector analysis, students then had to show how to use the speed and direction of each car after collision to determine the vector components of momentum (or speed) for each car. To determine the speed of the car, students were required to show how the momentum of each car after collision could be equated to the momentum of the same car just before impact.

Student work was scored using two holistic scoring scales. A marker first read a student's response and scored it on a 0 to 3 scale using the criteria described on the communication scale. Then, the same marker awarded the student's response a score of 0 to 4 from the content scale. A second marker then scored the same response using the procedure described above. The score for a student's response is determined by adding the two content scores together for a maximum of 8 marks and then adding it to the communication score, which is calculated by adding the communication scales together and dividing by two. The maximum score possible is 11 marks.

Students receiving full marks on this question most often used one of two approaches to solve the problem. After identifying the problem as one that could be solved using the Law of Conservation of Momentum, students using the more common approach calculated the momentum of each car after collision. They proceeded to determine the x and y components of momentum for each car. Then, students placed the x and y momentum components, respectively, into an equation that could be used to determine the velocity of each car just before impact. Students using this approach received full marks for describing in detail and showing how (using numbers) to calculate the velocity of each car before impact. Other students who received full marks described in detail how they would calculate the velocity of each car before impact, using words. Their descriptions provided detailed explanations of what assumptions, formula, equations, and procedures they would use to solve the problem.

Of the students who achieved the standard of excellence, 66.0% received a score of 9 or better out of 11. Of the students who achieved the acceptable standard but not the standard of excellence, 33.5% received a score of 6 or better out of 11 (54.5%). Of the students who did not achieve the acceptable standard, 86.7% received a score of 5 or better out of 11 (45.5%).

On this 11-mark question, the average mark was 5.0 or 45.6%.

For further information, contact Greg Hall or Lowell Hackman at the Student Evaluation Branch, 403-427-0010.